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ELECTRICAL SECTION.

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MINTING MACHINERY AND APPLIANCES

BY EDWIN S. CHURCH.
Superintendent of Machinery U. S. Mint, Philadelphia.

The electrical equipment of the new United States Mint is comparatively simple, similar devices being found in many modern shops, so therefore I will present to the Electrical Section of the Franklin Institute a general outline only of the mechanical operations involved in the coinage of money, together with a brief description of the various installations.

The equipment will include several new features, which as yet are in an experimental stage, and will not be alluded to in this paper.

The development of coining machinery is necessarily slow, since the manufacture of money is confined almost entirely to governmental institutions, which limits the de-

mand for this class of machinery. Again, in many of the coining operations, the judgment of the operator is of such importance that it is impossible to substitute apparatus which would eliminate this personal factor.

The necessity of accuracy and the difficulty in maintaining a uniform standard is appreciated only by those who are in daily touch with the work.

The mixing of gold and silver, while in a heated condition, with their respective alloys, casting into ingots, rolling and cutting into planchets, annealing and whitening, and finally the stamping, all depend, more or less, upon the skill and judgment of the operator.

No set rules can be laid down for this work that will give uniform results for the different melts, or even for two strips in the same heat, which often vary beyond the tolerance, although they have passed through identical operations, so far as human judgment can determine.

Again, the law compels us to work by weight, and since the blanks are cut from dies of the same size, the variation in density and hardness must be compensated for by varying the thickness of the blanks. Occasionally, blanks have been found, on calipering, where the lighter pieces measured about .0003 of an inch thicker than the heavier pieces.

Innumerable theories have been propounded for securing greater accuracy, new schemes suggested and tried, but ninety per cent. have failed, because, when tested from a practical standpoint they were found to be worthless.

It is, comparatively, a simple matter to secure good results from a small amount of metal when it is handled with extreme care in the melting and annealing furnaces, but when you attempt from data secured in this manner to frame rules for the working of tons of metal daily, some of which is hard and brittle, the rest tough and soft, the proposition is entirely different.

This was forcibly illustrated when experiments were made to eliminate the draw-bench and wood furnaces. These experiments were started two years ago, and it was only recently that the results justified the adoption of finishing rolls and automatic strip furnaces for silver.

The following table gives the weight, fineness, tolerance and diameter of all pieces coined at the mint at the present time:

Denomination.	Legal Weight. Grains.	Fineness. Per Cent.	Tolerance. Grains.	Tolerance. Per Cent.	Diameter.
Double Eagle	516	90	·50	·09	1·350
Eagle	258	90	·50	·19	1·050
Half Eagle	129	90	·25	·19	·850
Standard Dollar	412·5	90	1·50	·36	1·500
Half Dollar	192·9	90	1·50	·77	1·200
Quarter Dollar	96·45	90	1·50	·155	·950
Dime	38·58	90	1·50	·388	·700
Five Cents	77·16	75Cu			
		25Ni	3·00	·388	·800
One Cent	48·	95Cu			
		2½Sn			
		2½Zn	2·00	·416	·750

The tolerance is the amount the coin is allowed to vary above or below the legal weight in grains, and, as shown in the next column, the ratio of this amount to the weight of individual pieces is a varying quantity ranging from ·09 per cent., with the double eagle, to ·416 per cent. in the one-cent piece. Of course, the denomination in which the tolerance is the largest per cent. of the legal weight, is the easiest to coin; for instance, the one cent, as shown in table, ranks first in this regard, and the double eagle is the most difficult.

Although the regulations call for a certain thickness for the various denominations, it is not considered in the coining operations, since, if the diameters are kept intact, the thickness must vary with the density of the metal.

After the metal is properly alloyed it is run into ingots, and the ends are cut off by an appliance known as a topping machine, which is run by a 3 horse-power motor; the power is transmitted from the motor to the machine by means of a belt; this, together with the cutting-presses, is the only machine used in coining operations on which a belt is used.

Four of these machines will be required.

The ingots are then rolled out by break-down rolling mills which are driven by 50 horse-power motors, and then finished to their proper thickness by mills driven by 25 horse-power

motors. These motors are arranged with countershafts, running at 300 r.p.m., through the base. The pinions *A* and *B* are made of raw-hide, in order to reduce the noise. Six break-down and four finishing mills will be used to start operations during the first year.

The mills, as shown in *Fig. 1*, have 10 x 9-inch rolls, with 7-inch necks, and are made of chilled iron.

Experiments will soon be made to substitute steel rolls, but it is a question if the efficiency will be increased enough to justify the extra expense.

These rolling mills have several features which, to the best of my knowledge, are utilized only in mint operations. The adjustment is obtained by means of wedges situated under the lower roll, which is capable of adjustment in a vertical direction, and by means of a graduated dial the movement can be adjusted to ·0005 inches. All mills will, in the future, be fitted up with the solid wabbler instead of one consisting of three or more pieces. This reduces the excessive pounding, which cannot be eliminated from wabblers of the latter type.

To determine the proper speed for rolling has been a subject of considerable experiment. Two years ago, a rolling mill was constructed so that the speed could be varied. Velocities, ranging from 40 to 160 feet per minute, were tested, and, finally, 117 feet surface velocity of material passing between rolls was adopted. Faster than this causes difficulty for the operator who receives the strip, and there is also liability of the feeder passing two strips instead of one through the rolls.

The rolling mills will be substituted for the old-fashioned draw-bench and a 25 per cent. saving in the condemned silver blank will be possible. As yet this method for the gold denomination is in an experimental stage.

The strips are then cut into blanks by cutting machines, which are driven by 3 horse-power motors. Nine of these will be used.

During the rolling operation the strips are annealed by an automatic heating machine, which propels them through an oven heated by gas, and it should be noted that the

increase of standard blanks is largely due to the efficiency of this machine.

Before leaving the mechanical operations which have been alluded to in this article, I wish to emphasize the difficulty of proper annealing, which is a source of trouble to all workers in metal, and is no doubt due, to a great extent, to the difficulty in controlling the temperature and handling the material while in a heated condition.

In most establishments less thought and time is spent in perfecting this department than any other, yet we find, in the mint, that this is the most important operation through which the metal passes.

Any process, such as forging, drawing, rolling or spinning in which the metal is subject to considerable strain or pressure, tends to harden the material in a comparatively short time, and when we consider that it requires a 50 horse-power motor to reduce a silver strip, approximately $1\frac{1}{2}$ inches by $\frac{3}{8}$ inches by 4 feet, only ·016 inches during one passage, it would seem strange indeed if a considerable molecular change could not be detected. To restore the ductility to the metal, a constant temperature of the proper degree must be maintained, and without going into detail respecting the requirements of the various metals, the following is a general scheme which shonld be followed:

The proper degree of heat for the various metals must be distributed over the surface without relying upon the conductivity of the metal for equalization, and the flame must be non-oxidizing when gold or silver is to be worked with their alloys.

The work at the mint has shown that the old idea of annealers to allow the metal to "soak," after it has been brought up to its proper heat, is of no benefit, especially where the fineness has to be maintained within the government limits; the material should be withdrawn as soon as heated.

Gold is now annealed in the automatic furnaces by remaining in the flame approximately seven minutes—that is the time required in passing through. The wood furnaces required a strip to remain in the fire about forty

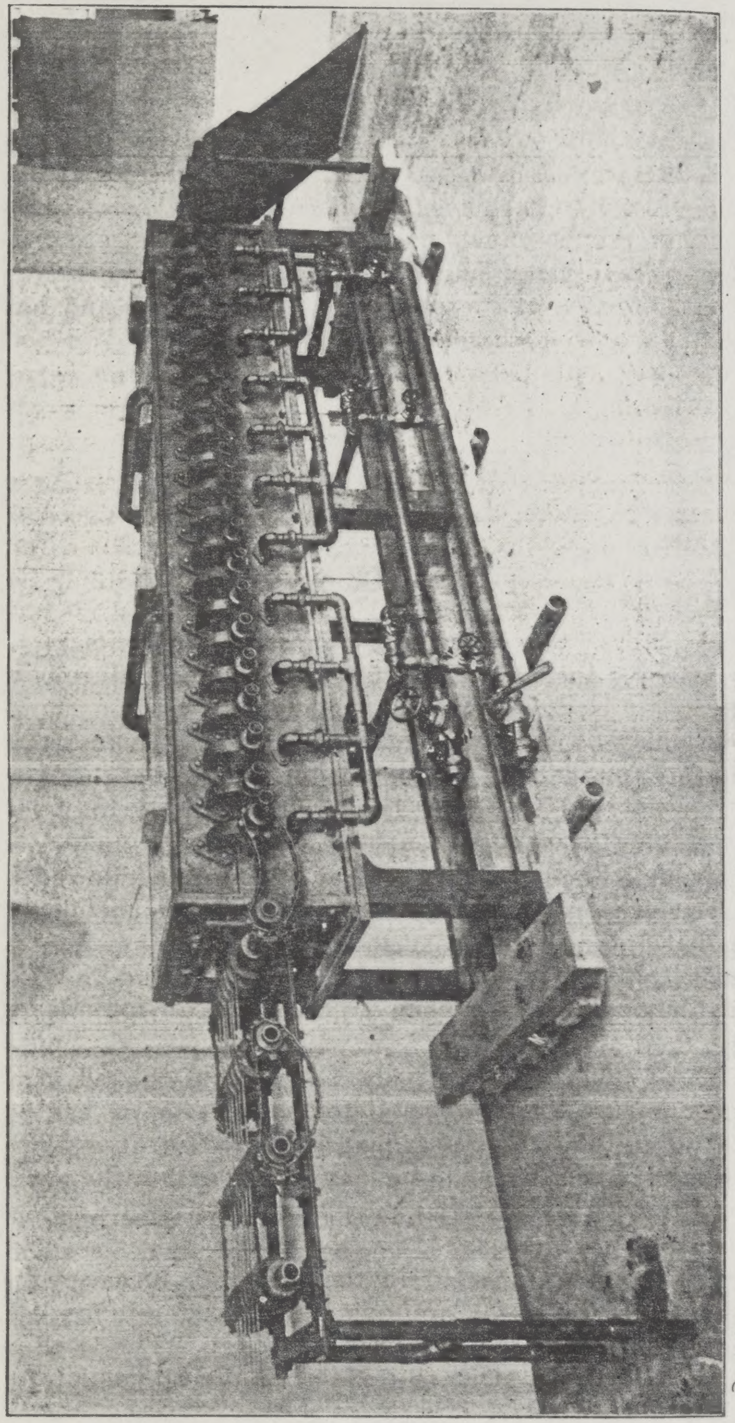


FIG. 2—Annealing furnace.

minutes. *Fig. 2* is a photograph of the first machine built of this kind, and is similar to the new ones, except that the cooling attachment is not shown. Instead of the strips being cooled by hand a fine spray of water is thrown upon them before they are exposed to the air, which prevents oxidization. They can then be handled without gloves or tongs.

The heating machine will be driven by ½-horse-power motor, and the variation in speed is secured by means of cones which run at 120 r. p. m. The reduction of speed is obtained by worm and worm wheel, as shown in *Fig. 3*.

The blanks are then upset by a machine, as shown in *Fig. 4*, driven by a 3 horse-power vertical motor. Nine of these were designed and built at the mint.

The planchets are then annealed by rotary-heating machines and cleaned with a diluted solution of sulphuric acid.

The furnaces are driven by ¼ horse-power motors geared into a shaft passing through a cone, and the power is transmitted to furnace by means of a belt. This scheme is shown in *Fig. 5*.

The rotary-heating machine (*Fig. 6*) consists of a wrought-iron cylinder surrounded by a cast-iron cylinder. The metal is carried through the outer cylinder by a worm and then dropped, in a heated condition into a receptacle and is ready for the bath.

The planchets, after the cleaning operation, are stamped. This is done by means of the coining press, which is, without doubt, one of the best-designed machines in the building, and is shown in *Fig. 7*.

The planchets are fed in the tube A by the operator, and placed in collar O by means of the fingers. The end of the travel of fingers is shown by the dotted position, L. The fingers are opened and closed at the end and beginning of the stroke by means of the friction-block, which travels in grooves.

The upper die, B, actuated by the horizontal beam through the toggle, gives the obverse impression, while the lower die, C, imprints the reverse side. As the dies come

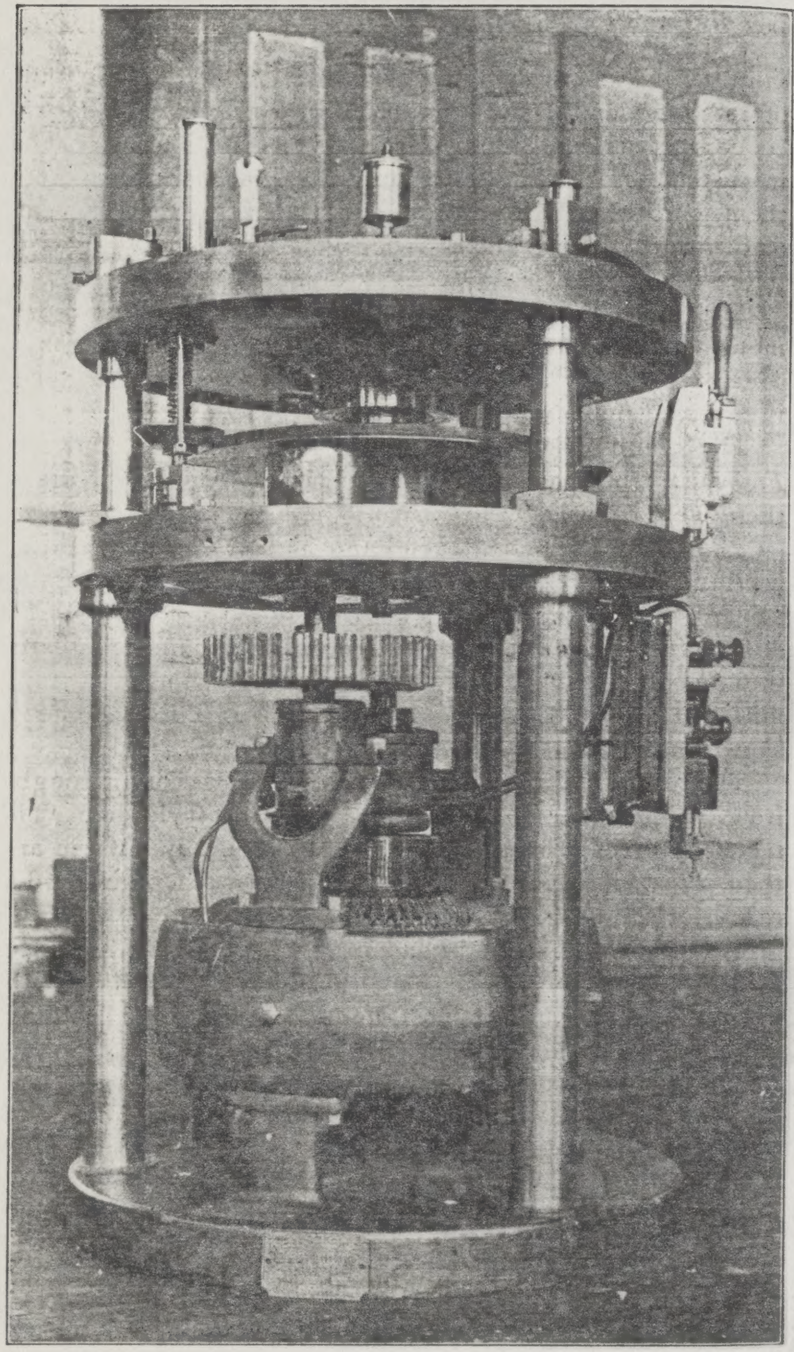


FIG. 4—Upsetting machine.

together the metal is pressed in the grooves of collar, C, giving the reeding on the outer edge. After the stamping operation is completed the fingers return to their first position, J, and on feeding the next planchet pushes the stamped coin aside, which has been forced out of the collar by the raising of the lower die.

On account of the excessive pressure amounting approximately to 160 tons for a dollar, the bearings of the toggle must be very hard, and lapped to a proper bearing.

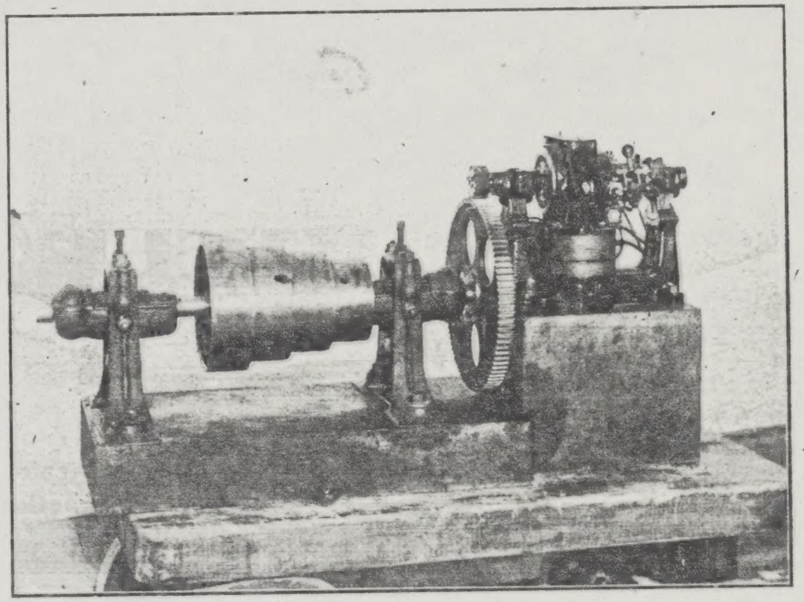


FIG. 5—Geared speed-reducer.

Twenty-three coining presses are to be installed: the larger ones, capable of coining all denominations, will be equipped with $7\frac{1}{2}$ horse-power motors, and the small presses, which are used for denominations up to and including quarter dollars, are equipped with 3 horse-power motors.

The above is only a general description of minting operations, omitting the automatic weighing machines, adjusting, ringing, or the test for resonance, and the several

precautions necessary to preserve the standard of excellence expected of the Mint.

As a result of the new annealing operations, a noticeable change has been observed by the mint officials in the color and appearance of the gold coins. This effect is due to the naphtha gas flame, which does not oxidize the copper used as an alloy, consequently the gold has a much deeper color, preserving the true color of the government alloy.

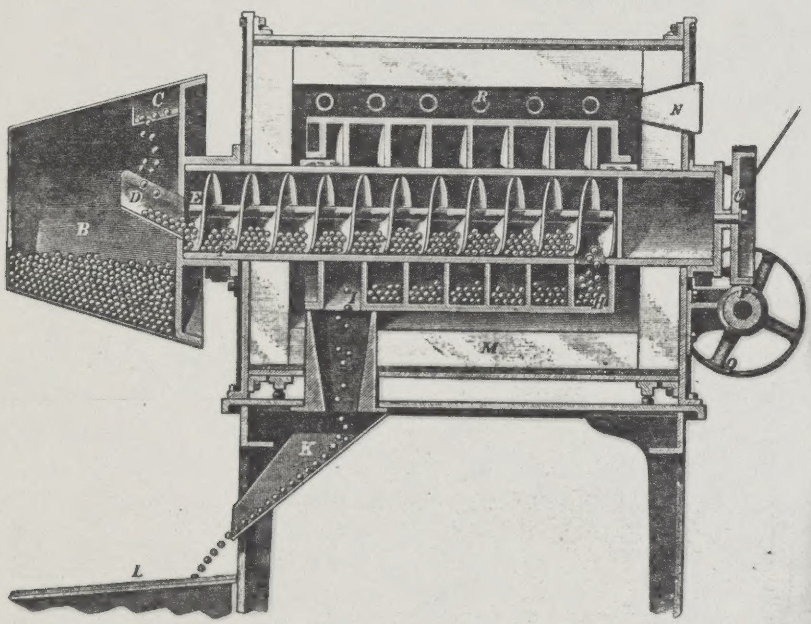


FIG. 6—Rotary furnace.

These improvements in annealing are due to the efforts of the American Gas Furnace Company, of Elizabeth, N. J., the coöporation of the Treasury officials and the determination of the Superintendent of the Mint to secure the best equipment possible for the new building.

The following is the number and size of the motors which will be used for coining operations:

	H. P.	TOTAL H. P.	
3 —	3 —	9	open-type countershaft through base.
4 —	7½ —	30	" " " " "
1 —	15 —	15	" " " " "
2 —	25 —	50	" " " " "
1 —	35 —	35	" " " " "
6 —	50 —	300	" " " " "
14 —	7½ —	105	" "
34 —	3 —	102	" "
1 —	10 —	10	" "
2 —	15 —	30	" "
1 —	5 —	5	" "
4 —	¼ —	1	" "
12 —	½ —	6	" "
2 —	10 —	20	enclosed type.
2 —	20 —	40	semi-enclosed type.
1 —	12 —	12	" " "
4 —	10 —	40	" " "
2 —	10 —	10	" " "
1 —	3 —	3	" " "
1 —	5 —	5	open reversible.
2 —	3 —	6	" "
1 —	10 —	10	suspended from ceiling.
1 —	5 —	5	" " "
9 —	3 —	27	vertical type.
111		876	

SPECIAL CONNECTED MACHINES.

There are two directly connected sets. Capacity of dynamos, five hundred ampères at 5 volts each; fields to be excited from 220 volts.

The following are a few special motor connections: *Fig. 8*, 30 x 30-inch x 6-inch planer; *Fig. 9*, milling machine; *Fig. 10*, 24-inch lathe; *Fig. 11*, blower for gas purposes.

On account of the 220 volts which are used for power and lighting purposes, the starting boxes for all motors except those for 50 horse-power are provided with magnetic blow-outs, overload, and no voltage release. The contact buttons are also staggered.

The boiler plant as shown in *Fig. 12* consists of eight boilers, 150 horse-power each, arranged in four batteries carrying 125 pounds pressure and equipped with down draft furnaces. The gases from boilers can be passed through fuel economizer to an exhaust fan or directly to chimney.

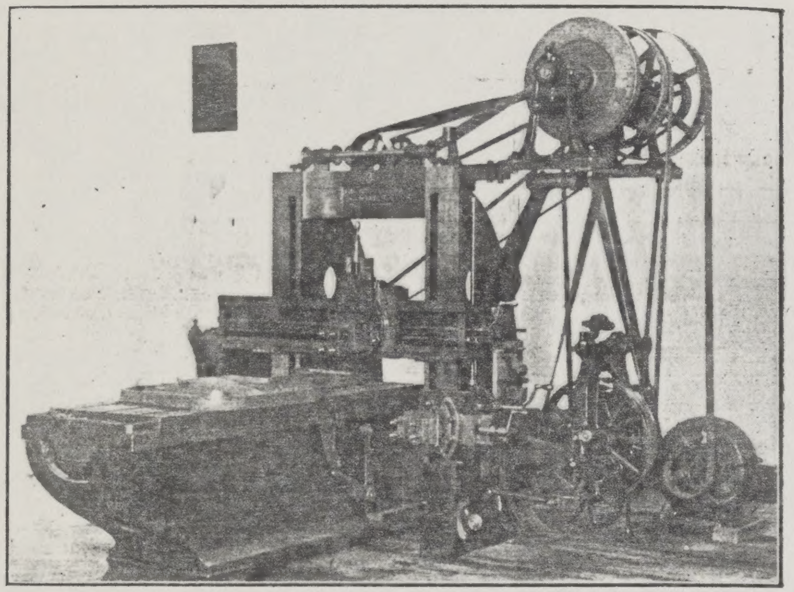


FIG. 8—30″ x 30″ x 6′ planer.

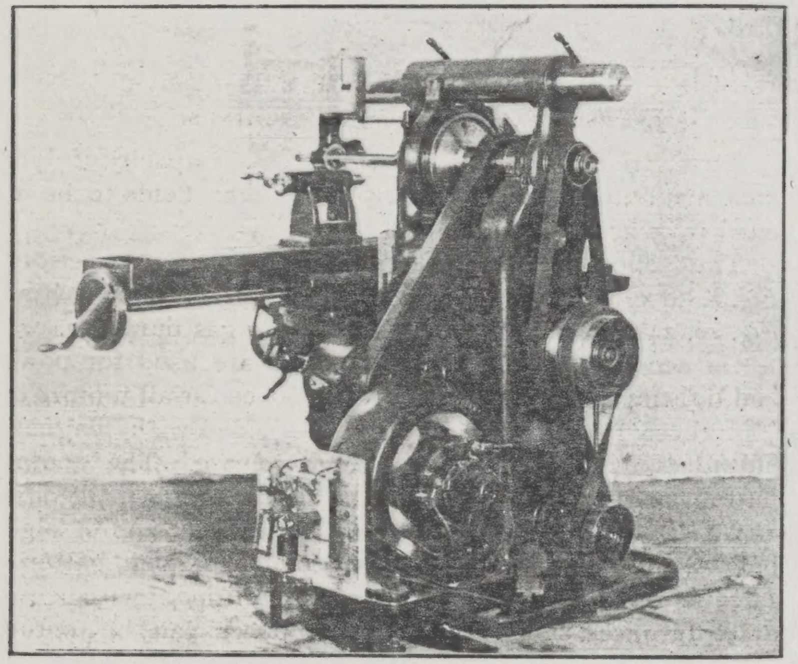


FIG. 9—Milling machine.

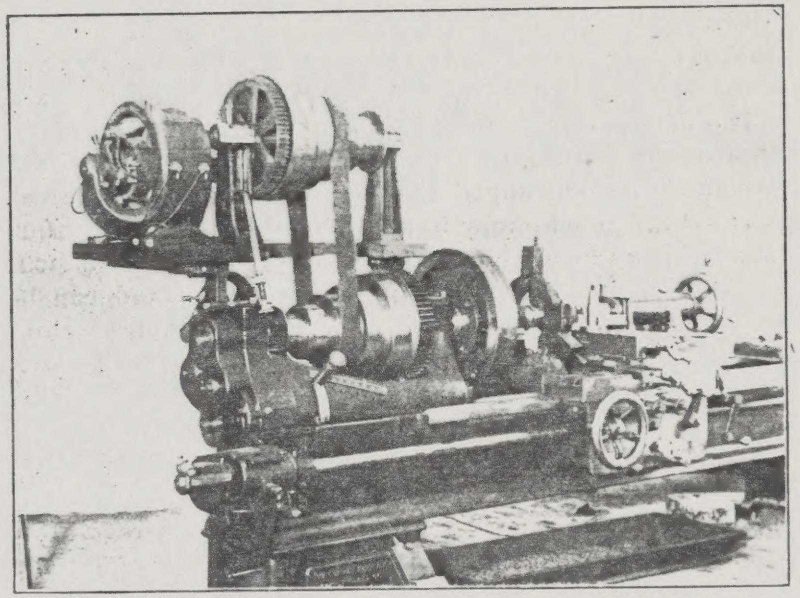


FIG. 10—24″ lathe.

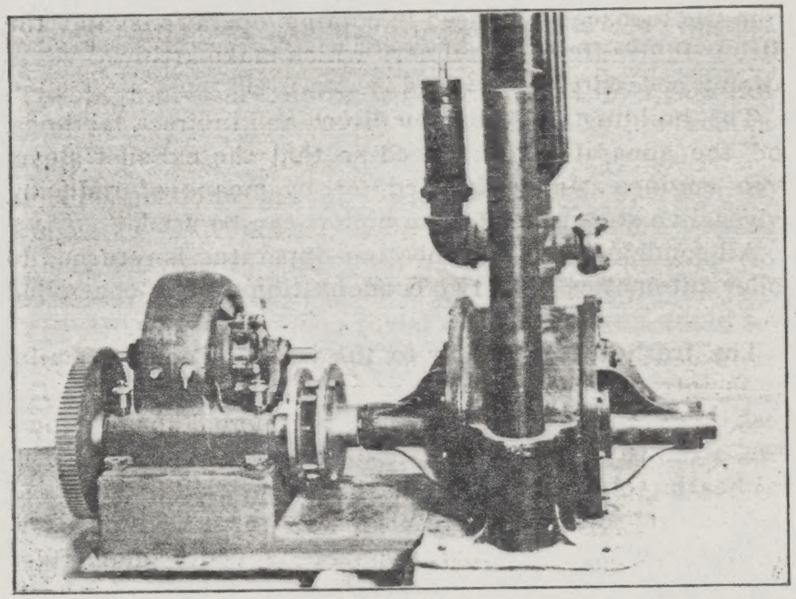


FIG. 11—High-pressure blower.

The economizer consists of twenty sections of ten tubes 4 inches diameter each and are cleaned by means of scrapers driven by two vertical engines.

The feed water is heated by a 700 horse-power vertical exhaust steam feed water heater, and together with the economizer is so arranged that any or all can be by-passed.

The draft to chimney is augmented by an 8 foot fan, capacity of 2,500 cubic feet of gas, at a temperature of 300° F. per minute. The fan runs at 200 r.p.m. and can be parted at an angle of 45° to the horizontal through center of shaft, to facilitate repairs. It is driven by two 25 horse power vertical engines and so arranged that either one can be thrown into service.

There is also provided a steam nozzle for chimney draft capable of giving a draft equal to 1 inch of water column. The amount of draft is regulated by damper regulators connected to steam drum and also by throttling of the fan engines.

The chimney will not only be used for disposing of gases from the boilers, but also the products of combustion from the furnaces, etc. used in coming operations and the nitrous fumes from the refinery which make artificial ventilation a necessity.

The building is heated by direct and indirect methods, and the apparatus is arranged so that the exhaust steam from engines can be utilized, or by means of reducing valves, live steam direct from boilers can be used.

All condensation from heating apparatus is returned to boiler automatically by two condensation pumps controlled by a pump governor.

The fresh hot-air supply to the various rooms in building is introduced after passing over heated coils, and the fresh air is taken through openings provided for that purpose, after passing through air filters and delivered to central heating chamber by means of fans.

All steam piping is in duplicate, and arranged for carrying 125 pounds for generating sets, seventy pounds for pumps and engine fans and atmospheric pressures for heating system.

Two steam horizontal condensation pumps, $7\frac{1}{2} \times 4\frac{1}{2} \times 6$ inches, and two vertical boiler feed pumps, $9 \times 6 \times 6$ inches, are installed with their respective piping, so that any or all can be used.

The generating plant consists of four direct connected generating sets, as follows:

Two 200 kilowatts, 100 r.p.m.; one 150 kilowatt, 135 r.p.m.; one 75 kilowatt, 150 r.p.w.

The engines are of the tandem, compound, non-condensing Corliss type, connected directly to their respective generators, and their guaranteed efficiencies are as follows:

200 kilowatts,	21½	pounds of water for indicated horse-power per hour.
150 kilowatts,	22	" " " " "
75 kilowatts,	23	" " " " "

The two 200 kilowatts are to be used for coining operations during the dav, the 75 kilowatts for night work, and the 150 kilowatts for lighting purposes. Practically, no provision is made for gas-lighting in the new building, and it will be necessary for the power plant to supply current at all hours of day or night.

Fig. 13 shows the general arrangement of the various sets.

The high-pressure piping is designed so that steam can be shut off any engine without interfering with the remaining sets.

The connections between the generators and switchboard are made by lead-encased, rubber-insulated cables, carried in ducts varying in size from 450,000 circular mils to 1,200,000 circular mils.

The switchboard is constructed of pink Tennessee marble, 2 inches thick, and is divided into panels, as follows: Four for generators, two for lighting circuits, and the remainder for the motor circuits throughout the building, The busbars for lighting and power circuits can be used independently, or by means of a switch can be connected. Double-throw switches enable the operator to throw generators on either lighting or power circuits. For the power circuit the circuit-breakers are of the one-throw type, consisting of two arms connected together, and switches are used in conjunc-

tion. The lighting panels have the independent arm, double-throw-type circuit-breaker, and are used without switches.

As far as possible each department has its independent system for power purposes, and as the coining operations consume the major portion of the power, the rolling room alone is supplied with four independent circuits capable of delivering over 500 horse-power. This room is equipped with the 50 and 25 horse-power motors, together with the 3 horse-power motors for the cutting presses.

Twenty-five feeders supply current for approximately 3,500 lights, the majority of which are 16 candle-power and about 400, 32 candle-power. Each of the feeders is supplied with a switch, or the entire lot may be thrown out by pulling one main switch.

Fifty-one telephones connected to a switch board controlled by an operator are installed. The system is of the complete central-energy type, and the operator is notified of a call by the dropping of a shutter connected to its respective phone.

An ink-writing telegraph register, capable of indicating an alarm from any one of thirty-five alarm boxes, is used in connection with fire-alarm gong in the office of the engineer and of the superintendent of machinery. The taps on the gong correspond to the station from which the signal is sent.

Thirty watchman's clocks are placed in various parts of the building for the protection of the immense amount of metal stored in the form of coin or bullion.

The signals are turned in by means of a handle causing a small dynamo at each station to send a current to its respective magnet.

Forty-one time-clocks, connected to a master-clock are installed in order to secure uniform time throughout the building.

A switch-board built of blue Vermont marble mounted on an iron frame-work is located in the guard's room in the basement.

On this board is mounted the fuse block, telephone wir-

ing, fire alarm recorder, American District and Western Union call-boxes, police-telegraph and city fire-alarm boxes and voltmeter switch for testing condition of the various storage batteries which supply the electrical apparatus throughout the building.

The storage battery plant, which is in duplicate, supplies the telephone exchange, fire-alarm system and time-clocks with current.

The battery consists of sixty cells connected to a circuit-changing switch, so that when the switch handle is thrown in one direction thirty of the cells will be thrown in series and made ready for charging. The other thirty are split up in five groups with different members of cells in each group: one supplying the telephone exchange; another, fire-alarm system; third, the gas machine; fourth and fifth, the time-clocks.

The circuit-changing switch is thrown in the other direction when the batteries are discharged, placing the duplicate set in service for the various apparatus.

The scheme for charging is arranged so that it can be done from one of the power panels in engine room which is equipped with circuit breaker and rheostat.

Eight elevators, seven for freight and one for passengers, driven by electric motors and provided with a top-and-bottom limit switch, slack-cable switch, safety switch in car and centrifugal governor, all being in series with the brake magnet and safety cut-out.

Four of these elevators, having a capacity of four tons each, are to be used for carrying the loaded trucks of metal to the various floors, and one is so arranged that by means of a back gear the speed can be reduced and its capacity doubled. This will be used for transferring heavy coining machinery varying in weight from three to seven tons.

The gas equipment includes furnaces, heating machines, etc., throughout the building, and a gas-generating plant.

The installation consists of two independent plants; the larger one has a capacity of 20,000 cu. ft. of gas per hour, has four generators arranged in two sets, and each set in turn is connected in tandem.

The smaller plant is to be used for the assay department, and has a capacity of 2,000 cu. ft. of gas per hour. This plant, in case of necessity, can be thrown in service with either one of the larger ones.

This system manufactures gas by vaporizing naphtha in the presence of warm air, and all the accessories to the vaporizer or generator are simply to keep the pressure and temperature of gas constant by heating the oil, air, and the gas after passing from the generator.

The accessories consist essentially of a feeding tank, which regulates the supply of oil to the generator; water-pressure regulator for forcing the oil from the storage to the feeding tank under constant pressure; the circulating pipes for heating the oil after it passes through the generator; the radiator for governing the temperature of the oil which circulates in the machine; the automatic cut-off, the function of which is to close instantly when the air-pressure is removed; the gas-discharge valve for starting the machine, and an air-supply valve for controlling the air to the pipes which connect with the spraying nozzle in the generator.

A thermometer in series with a storage battery and special valve controls the steam to heating chambers. Four storage tanks, with a total capacity of 32,000 gallons of naphtha, are buried below the basement floor for supplying the various machines with oil.

The number of pieces coined and value of same varies considerably in different mints and depends somewhat upon the local conditions. For the fiscal year ending June, 1900, the Philadelphia Mint coined 152,558,878 pieces, value of which was $71,378,477.61. The total coinage of all the mints was 184,373,793 pieces valued at $141,351,960.36. The coinage of nickel and bronze is confined to the Mint at Philadelphia, and 101,301,753 pieces of the value of $2,243,-017.23 were manufactured.

There is also considerable special work required, and during the same year 50,000 Lafayette souvenir silver dollars and 320,000 pieces in 20, 10 and 5 colones for the government of Costa Rica were stamped.

The Director of the Mint states that the chief increase of coinage for last year was in the subsidiary and minor coins, which surpassed all records and was no doubt due to the extraordinary activity of the retail trade throughout the country.

To handle such a vast quantity of metal, which in a year amounts to tons, not only becomes a mechanical problem but necessitates an elaborate system of checking, weighing, assaying and calculating.

The transportation of metal has grown to large proportions, and the Director of the Mint reports that for the last fiscal year the imports in gold and silver amounted to $79,-829,486.00 and the exports $104,979,034.00. This was in the form of bullion, ore and coin (both foreign and domestic.) The handling of coin causes considerable wear, and last year the loss to the government in recoining $6,662,524.85 in worn and uncurrent coin was $313,334.21.

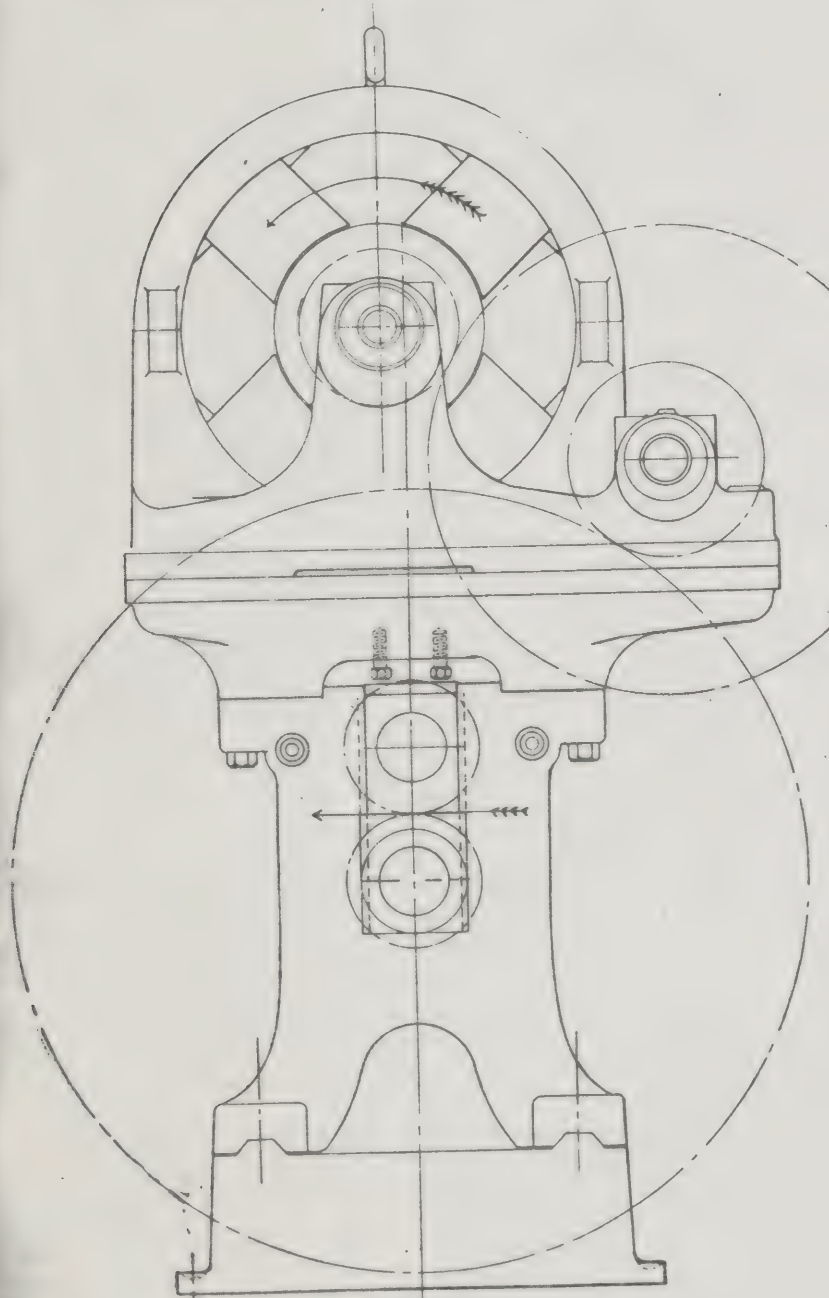
The care of all this money gives an endless amount of trouble. Huge steel vaults for its storage, equipped with all manner of safety devices, must be under constant surveillance. In the new building the largest and most improved vaults in the world are situated under the front running from 16th to 17th Streets.

Each vault has three doors: the front door, weighing about eight tons, is mounted on ball bearings; the other two doors are arranged in one set and are somewhat lighter than the front one. Four combination locks are used, which can be adjusted to independent combinations.

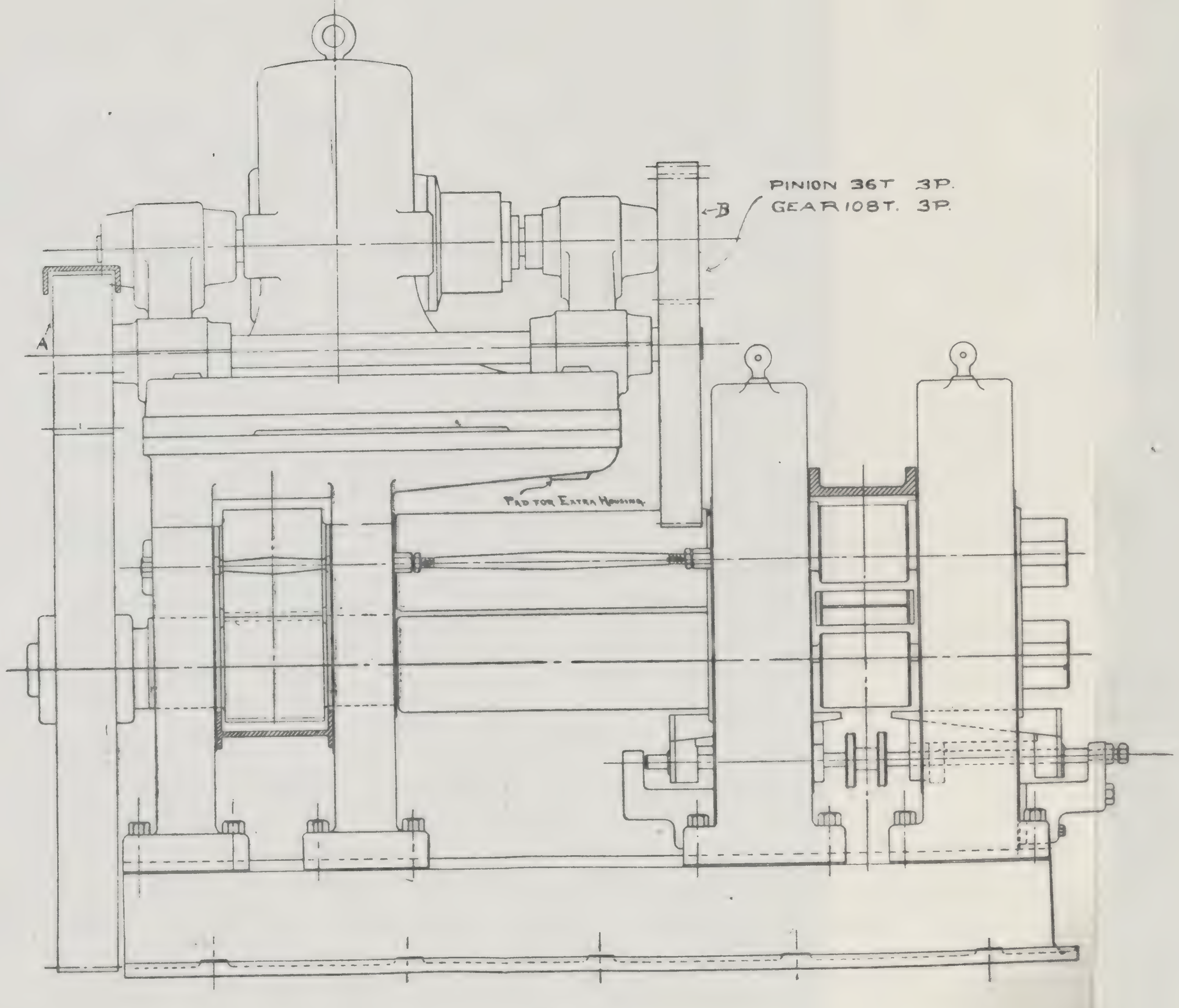
But with all these appliances for the safety of the many millions, the government must depend more or less on the honor of its employés. Considering the number of men employed, the vast quantity of precious metals handled, it is remarkable how small an amount has been lost.

SOME CHEMICAL MYSTERIES.

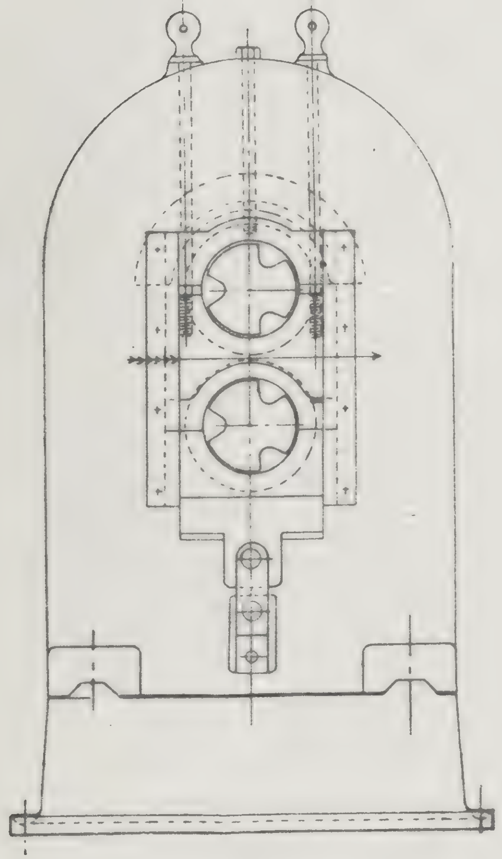
It has happened more than once that just as we had firmly established our science upon a basis which seemed as unyielding as the Biblical rock, and had toilfully formulated theories that explained all phenomena with unvarying simplicity, some obscure experimentalist made a discovery which by no



Motor end.



Front view.



Roll end.

FIG. 1—10″ x 9″ ROLLING MILLS, U. S. MINT, PHILADELPHIA.

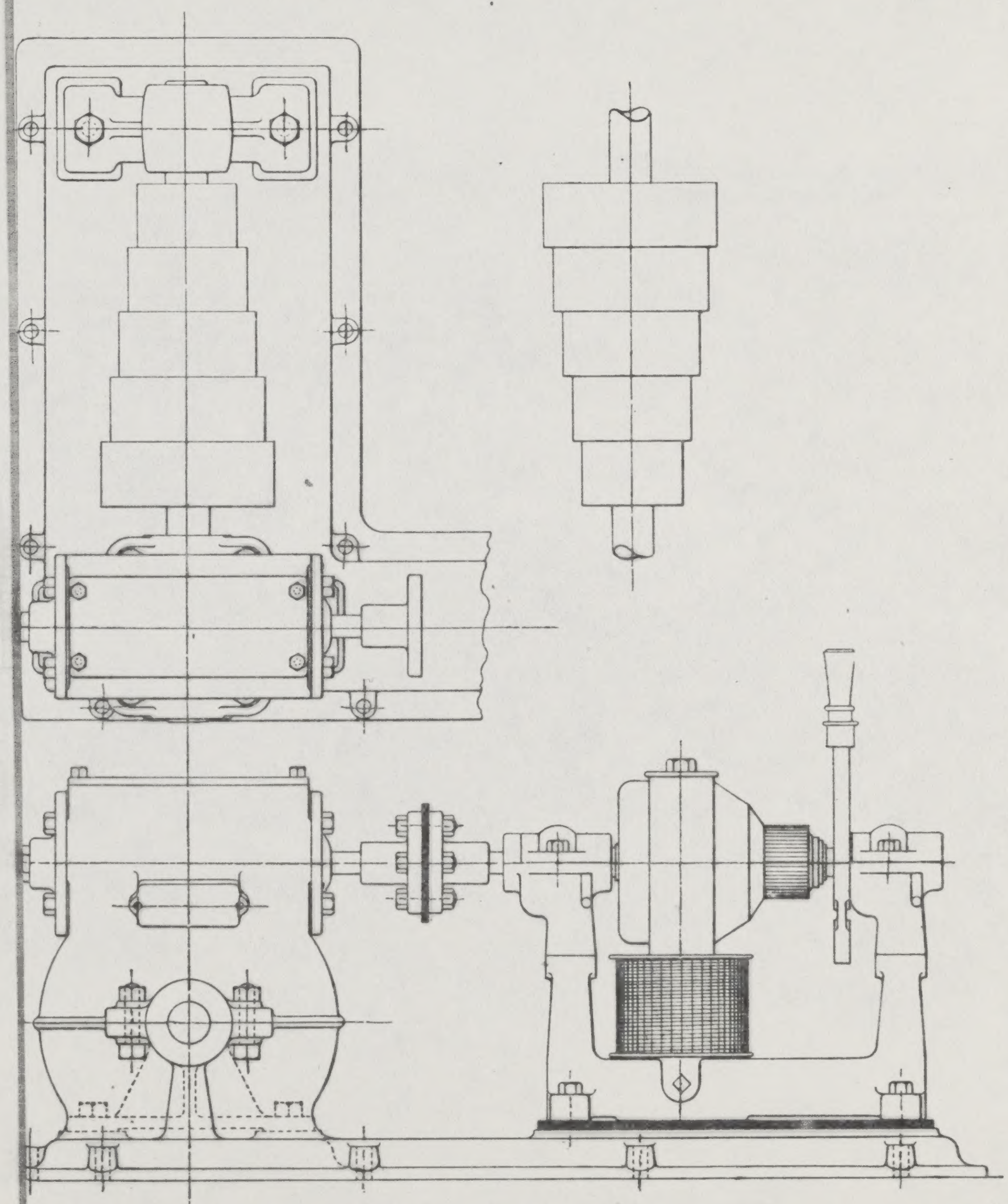
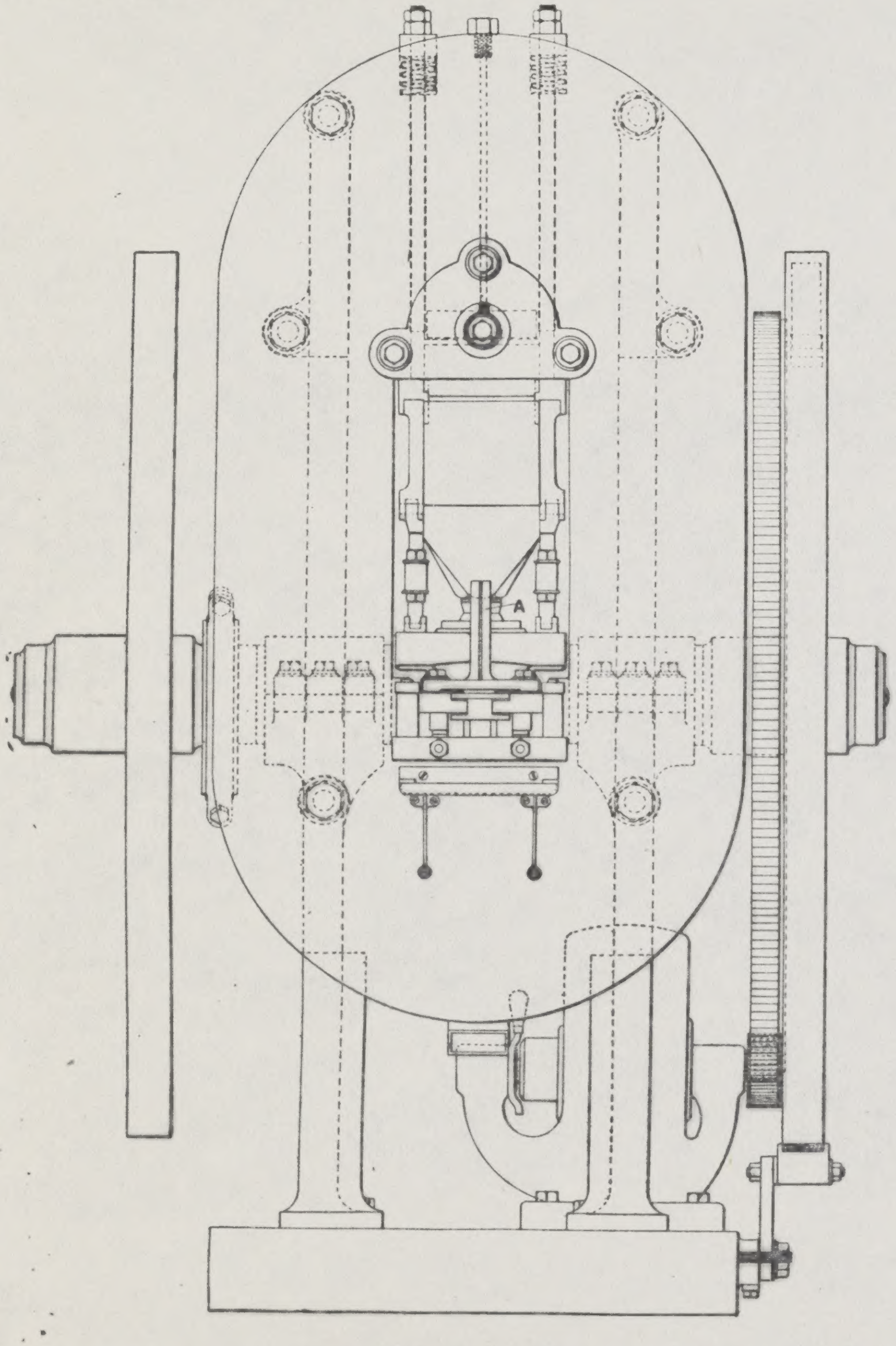
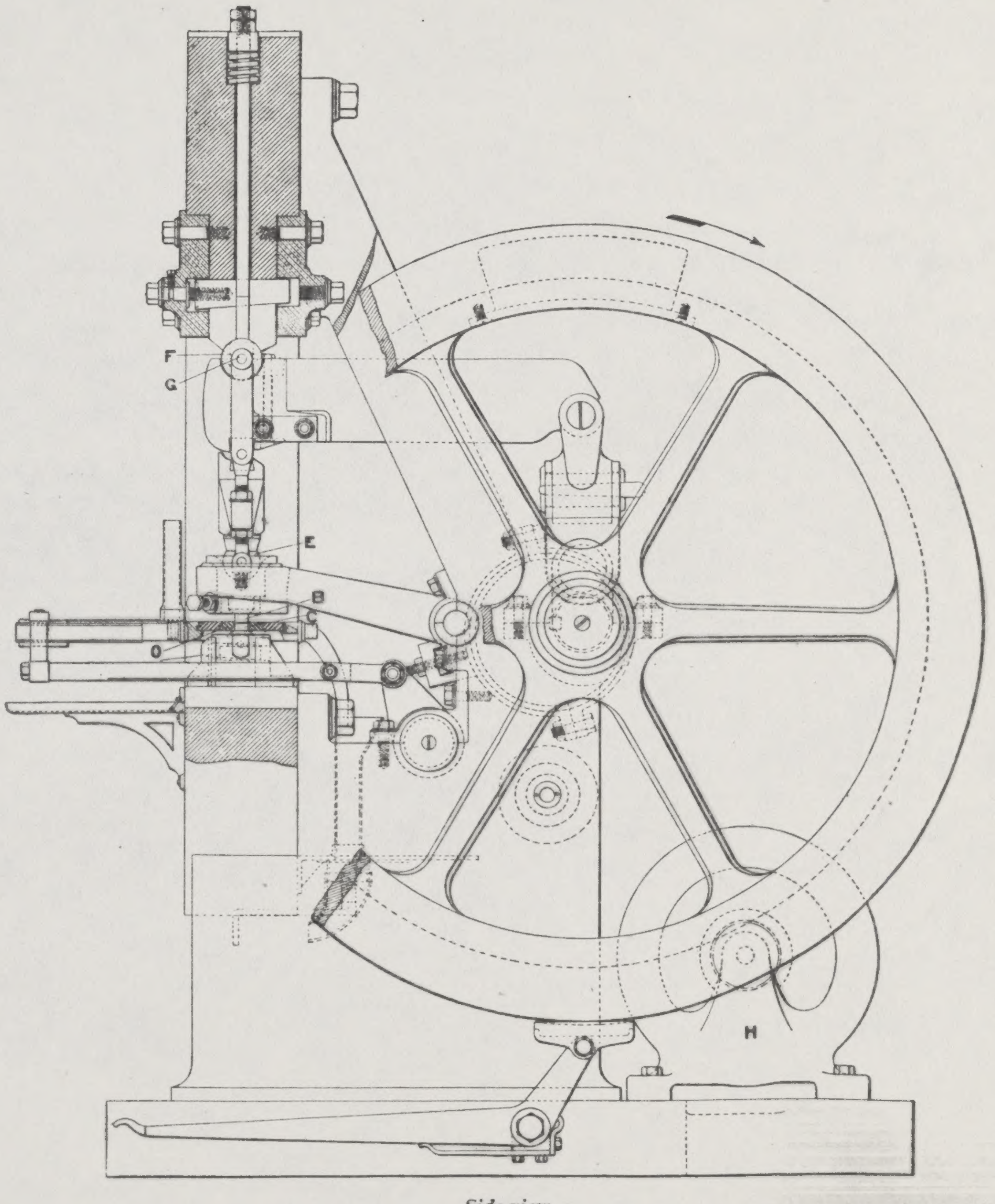


Fig. 3—Worm-gear drive for the annealing ovens.



Front view.



Side view.

FIG. 7—COINING PRESS.

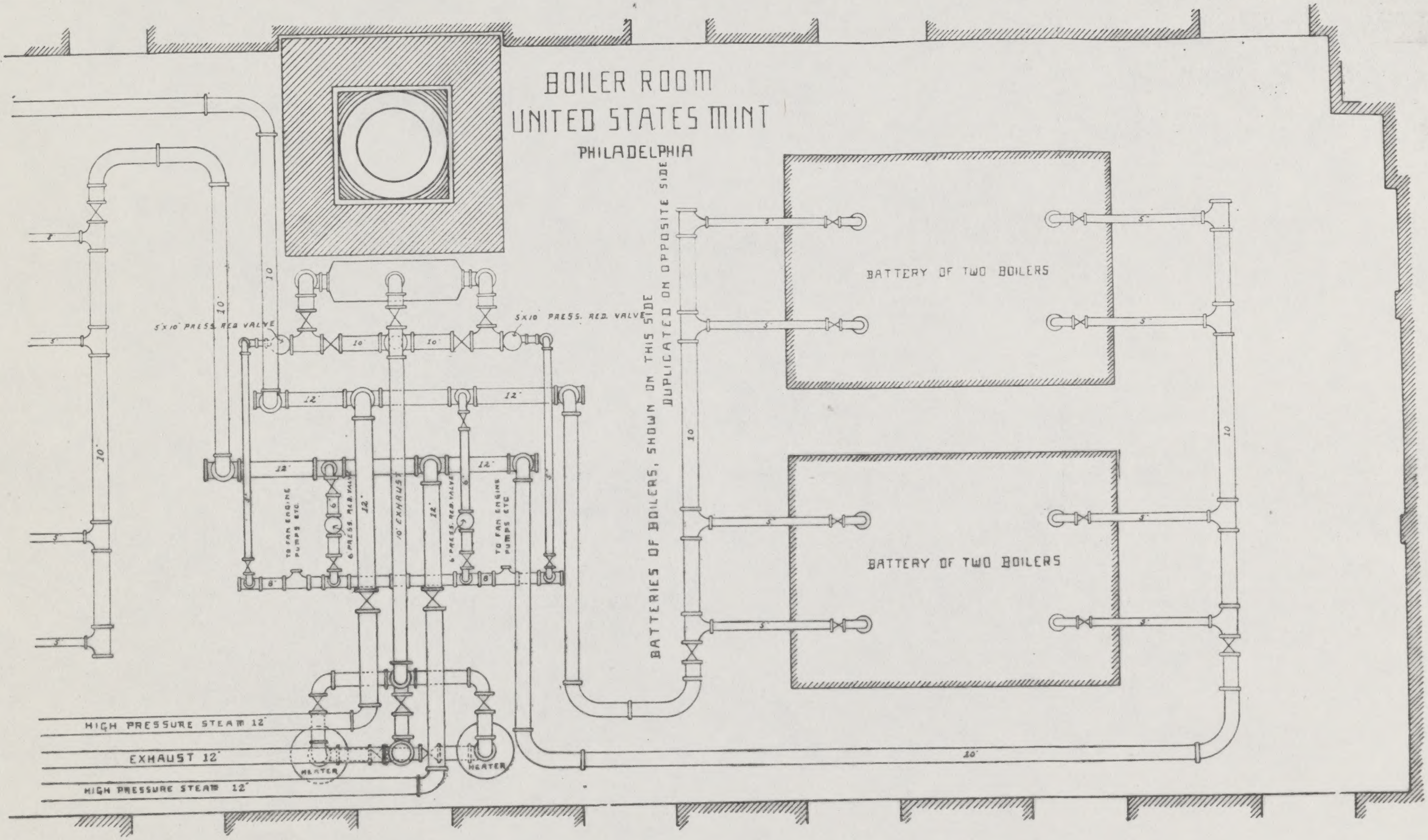


FIG. 12—PLAN OF BOILER ROOM, U. S. MINT, PHILADELPHIA.

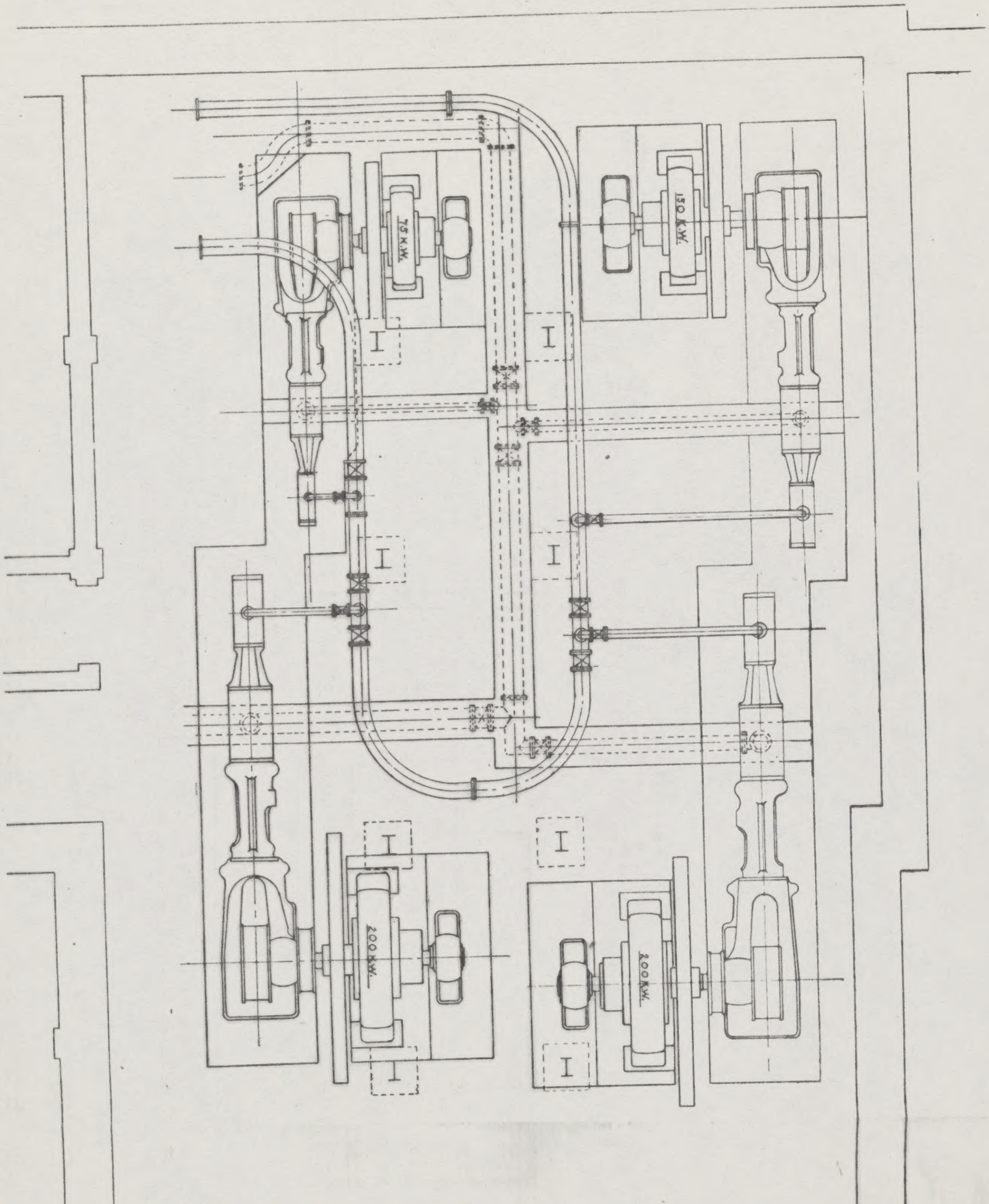


Fig. 13—Plan of engine room, U. S. Mint, Philadelphia.